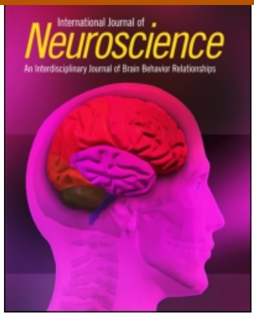

International Journal of Neuroscience

ISSN: 0020-7454 (Print) 1543-5245 (Online) Journal homepage: https://www.tandfonline.com/loi/ines20

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To cite this article: Danique L.M. Radder, Ingrid H. Sturkenboom, Marlies van Nimwegen, Samyra H. Keus, Bastiaan R. Bloem & Nienke M. de Vries (2017) Physical therapy and occupational therapy in Parkinson's disease, International Journal of Neuroscience, 127:10, 930-943, DOI: 10.1080/00207454.2016.1275617

To link to this article: https://doi.org/10.1080/00207454.2016.1275617

Accepted author version posted online: 22 Dec 2016.
Published online: 04 Jan 2017.

INTERNATIONAL JOURNAL OF NEUROSCIENCE, 2017
VOL. 127, NO. 10, 930–943
http://dx.doi.org/10.1080/00207454.2016.1275617

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ORIGINAL ARTICLE

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Physical therapy and occupational therapy in Parkinson's disease

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ABSTRACT
Current medical management is only partially effective in controlling the symptoms of Parkinson's disease. As part of comprehensive multidisciplinary care, physical therapy and occupational therapy aim to support people with Parkinson's disease in dealing with the consequences of their disease in daily activities. In this narrative review, we address the limitations that people with Parkinson's disease may encounter despite optimal medical management, and we clarify both the unique and shared approaches that physical therapists and occupational therapists can apply in treating these limitations.

ARTICLE HISTORY
Received 13 December 2016
Accepted 19 December 2016

KEYWORDS
Physical therapy; occupational therapy; Parkinson's disease; patient-centered care; multidisciplinary care

Introduction

Current medical management is only partially effective in controlling the symptoms and signs of Parkinson's disease (PD). Medication mainly targets impairments related to dopaminergic lesions, and is therefore not effective for impairments that are largely related to non-dopaminergic lesions in PD, such as impaired balance or dementia [1]. Moreover, in later stages of the disease, medication becomes less effective or cause complications like disabling dyskinesias, which limits further dose increases [2]. Consequently, even people with Parkinson's disease (PwP) with optimal medical management face considerable and varied problems in daily activities [3,4].

The extent to which PwP experience problems in daily functioning cannot be predicted solely by the severity of impairments, because the health condition interacts with personal factors (i.e. coping strategies, preferences and attitudes) and contextual factors in the environment (i.e. physical, social and societal). This interaction between health condition, functioning and influencing factors is illustrated in the biopsychosocial model of the International Classification of Functioning, Disability, and Health (ICF) of the World Health Organization (Figure 1) [5]. The ICF classification provides a multidisciplinary framework and terminology (names and codes) for the description of health and health-related problems. In comprehensive client-centered care, attention to all factors included in the ICF is essential. Consequently, a wide variety of healthcare disciplines can be involved in PD care [6,7]. Physical therapy (PT) and occupational therapy (OT) are examples of commonly engaged allied health professions that are often part of the multidisciplinary treatment team, aiming to support PwP to deal better with the consequences of their disease in daily activities. Although closely related, the focus of these two professional disciplines is actually different. In this narrative review, we describe the latest evidence-based treatment options for PT and OT. Moreover, we will emphasize both the shared and unique roles of these professions in PD care.

The impact of Parkinson's disease

PwP experience problems in multiple domains that can either be a consequence of the disease itself, from PD medication, or from inactivity [8,9]. In this paragraph, we will review the impact of PD using the ICF classification for problems relevant to PT and OT (Tables 1 and 2).

Impairments in functions

PD is characterized by motor symptoms including bradykinesia, hypokinesia, rigidity and tremor [10]. Problems with gait start to occur in the early stages of the disease [11]. Characteristic impairments include an asymmetrically reduced or absent arm swing, a stooped posture, an asymmetrical step size and difficulties turning around in the standing or recumbent positions [12]. As the

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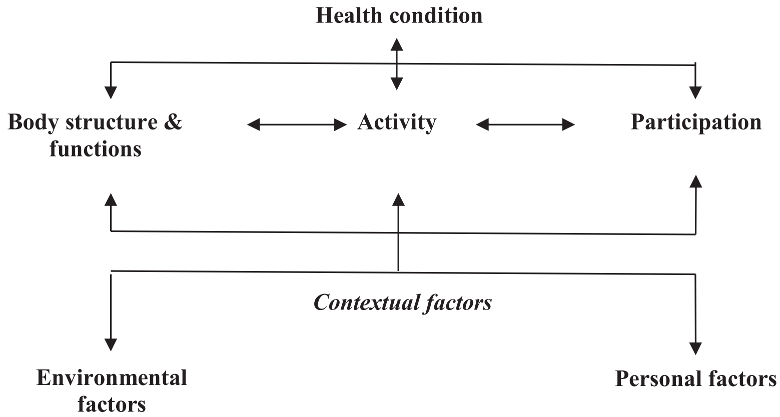

Figure 1. Model of ICF.

disease progresses, the gait pattern becomes slower and the typical Parkinsonian gait develops with shuffling and short steps, a bilaterally reduced arm swing and slow en bloc turns. Up to 80% of PwP experience festination or freezing, most often presented as shuffling with small steps [13,14]. Another highly debilitating example of motor impairment is postural instability, which usually becomes evident several years after the onset of the first motor symptoms. Both freezing of gait and postural instability may result in falling, leading to a number of negative consequences [15]. Falling frequently leads to significant injury and hospital admissions [16]. Moreover, falling is associated with increased fear of falling, disability, psychological problems and reduced quality of life [17]. Finally, physical capacity, which is a combination of muscle strength, muscle tone, muscle endurance, exercise tolerance and joint mobility, is often reduced or at risk in PD [18]. The fact that PwP are inclined towards a sedentary lifestyle may play a role in the development of these problems [9].

In addition to the impairments in motor functions, PwP also experience a wide range of non-motor symptoms, including depression, cognitive impairment (e.g. executive dysfunction and dementia), apathy, visual

Table 1. The impact of PD: possible impairments in functions.

b1: mental functions
1. Delirium (b110)
2. Dementia (b117)
3. Impairments in temperament and personality (b126)
4. Impairments in energy and drive functions, e.g. reduced motivation and impulse control* (b130)
5. Sleep impairments (b134)
6. Reduced attention (b140)
7. Reduced memory (b144)
8. Impairments in emotion, e.g. anxiety* (b152)
9. Impairments in perceptual functions, e.g. reduced visuo-spatial perception and hallucinations* (b156)
10. Impairments in higher level cognitive functions, e.g. in planning, decision-making and mental flexibility (b164)
11. Impairments in mental functions of language, e.g. verbal perseveration (b167)

b2: sensory functions and pain
- Seeing impairments, e.g. visual acuity* (b210)
- Dizziness* (b240)*
- Impairments in smell (b255)
- Proprioceptive function (b260)
- Tingling (b265)
- (Central) pain (b280)

b3: voice and speech functions (b3)
- Reduced pitch and loudness of voice (b310)
- Impaired articulation (including dysarthria) (b320)
- Reduced fluency of speech (b330)

b4: functions of the cardiovascular and respiratory systems
- Impairments in blood pressure (e.g. orthostatic hypotension*) (b420)
- Reduced exercise tolerance* (b455)

b5: functions of the digestive system
- Impaired ingestion, e.g. drooling, vomiting* and impaired swallowing (b510)
- Constipation* (b525)
- Reduced weight maintenance (b530)

b6: genitourinary and reproductive functions
- Impaired urination, e.g. (urge)incontinence* (b620)
- Impaired sexual functions, e.g. impotence and increased sexual interest* (b640)

b7: neuromusculoskeletal and movement-related functions
- Reduced joint mobility * (b710)
- Reduced muscle power* (b730)
- Impaired muscle tone functions, e.g. rigidity and dystonia (b735)
- Reduced muscle endurance* (b740)
- Impaired motor reflex functions (b750), e.g. simultaneous contraction of antagonists
- Reduced postural responses (b755)
- Reduced control of voluntary movements (b760), e.g. dysdiadochokinesia, reduced 'motor set' causing starting problems and reduced or absence of internal cues causing problems in automated, sequential movements
- Impaired involuntary movement functions (b765), e.g. bradykinesia, (resting) tremor and dyskinesia*
- Impairments in gait patterns, e.g. asymmetry, freezing, reduced step length, velocity, trunk rotation and arm swing (b770)
- On/off periods* (b798)

b8: functions of the skin and related structures
- Impairments in sweating and sebum production (b830)
- Impaired sensations related to the skin (pins and needles) (b840)

Note: Coding and terminology according to the ICF classification. The impairments in bold can (partly) be addressed by the physical therapist.
*Secondary impairments (partly) due to primary impairments and medications.

Table 2. The impact of PD: possible activity limitations and restrictions in participation.

Main domain		Examples of sub domains
d1	Learning and applying knowledge	Acquiring skills (d155), writing (d170), solving problems (d175) and making decisions (d177)
d2	General tasks and demands	Undertaking multiple tasks (d220), carrying out daily routine (230), handling stress and other psychological demands (d240)
d3	Communication	Speaking (d330), producing non-verbal messages (d335), writing messages (d345)
d4	Mobility	Changing and maintaining body position (d410-d429), carrying, moving and handling objects (d430-d449), walking and moving (d450-d469), moving around using transportation (d470-d489)
d5	Self-care	Self-care, e.g. washing oneself (d510), toileting (d530), dressing (d540), eating (d550) and drinking (d560)
d6	Domestic life	Shopping (d620), preparing meals (d630) and doing housework (d640)
d7	Interpersonal interactions and relationships	Basic interpersonal interactions (d710) and particular interpersonal relationships with strangers, formal persons, family and husband or wife (d730-d779)
d8	Major life areas	Education (d810-839), work and employment (d840-d859) and economic life (d860-d879)
d9	Community, social and civic life	Recreation and leisure (d920), religion (d930) and political life (d950)

Note: Coding and terminology according to the ICF classification. The areas in bold can be (partly) addressed by the physical and/or occupational therapist.

impairments, fatigue and sleep problems [19]. Although these symptoms are less well-known, they represent a huge burden for PwP, compromising daily activities and quality of life [20,21]. Non-motor impairments can be present in the early stages of the disease or may even precede the expression of motor symptoms [22].

Limitations in activities

Limitations in daily activities may start in an early disease stage and evolve as the disease progresses [23]. Impairments in function (as described above) affect activities of daily living like walking, transfers and manual activities. Transfers (e.g. activities like rising from and sitting down onto a chair, getting in or out of bed and turning over in bed) are complex composite movements and PwP often experience difficulties performing these normally automatized movement sequences [24]. Factors related to motor impairment that are likely to contribute, are weak limb support against gravity, poor timing of velocity and reduced muscle power [25].

Also, manual activities are complex movements, requiring a combination of sequentially executed submovements. In PD, the fluency, coordination, efficiency and speed of reach of dexterous movements are often diminished. Impaired timing and integration of movement components play a role, as well as impaired regulation of the necessary force, impaired precision grip and apraxia [26–28]. In addition to these problems, tremor can affect manual activities. A resting tremor generally disappears or diminishes when a movement is initiated. However, the tremor can re-emerge in isometric action of the muscles, for example when holding an object for a longer period of time. In some PwP, an action tremor affects the entire range of a voluntary movement [29].

Limitations might be more apparent in complex daily activities like eating, dressing, shopping and gardening because the attention load and mental flexibility required for these activities can further constrain motor performance [30]. Non-motor impairments also affect daily activities, such as visual deficits (i.e. impaired contrast sensitivity) and visuo-spatial difficulties which may lead to a reduction in (physical) activity [31,32]. Impairments in executive functions compromise the planning and organization of complex tasks and routines. This might become evident in activities like managing medication, planning a trip or administrative tasks.

Restrictions in participation

Inevitably, PD restricts PwP in participating in meaningful activities related to work, leisure or community and social life [33–37]. Many activities require too much time and effort, cause embarrassment, or are considered too dangerous by those close to them [38]. PwP that are employed often experience difficulties in their work and stop working early [39]. Fatigue is one of the main problems experienced in the work environment [40–42] and is also associated with reduced participation in leisure activities [43].

Personal and environmental factors

Personal abilities and environmental factors can act as barriers or facilitators in activity performance and participation of PwP. For example, in the physical environment, limitations can be caused by the layout and availability of space, the height of furniture, the availability of visual cues and the quality of lighting. Narrow spaces and darkness provoke freezing [44] and a stressful context or perceived time pressure aggravates symptoms like tremor and freezing [45]. In addition, for actual participation, not only the capacity to plan and perform activities is important, but also the motivation and coping style [38,46]. Moreover, to maintain participation, adequate social support is essential [47].

Treatment options for physical therapy and occupational therapy

Unique roles and similarities

Both PT and OT aim to improve functional independence and participation. In PT, the main focus is on mobility-related activity limitations, including the following core elements: physical capacity, transfers, manual activities, balance and gait. Posture, which is also an important target for PT treatment, is included as part of the other core areas [48]. PT aims to increase (or maximize) movement quality, functional independence and general fitness while preventing (or minimizing) secondary complications and optimizing safety. As such, PT includes support for self-management and participation in movement related activities [48].

The occupational therapist focuses on enabling performance and engagement in meaningful activities and roles at home and in the community [7,49–51]. These activities and roles can be classified in activities related to the home environment like self-care and functional mobility; work, either paid or unpaid; and leisure activities, for example shopping, visiting a restaurant or a theater [50]. Depending on the needs of the caregivers, the role of occupational therapist extends to enabling caregivers to support and supervise the patient in daily activities while considering their own well-being [7,50,52].

Referral to physical or occupational therapy

Timely referral to either discipline is recommended because difficulties in daily life can be present in early stages of PD [4]. From the diagnosis onwards, PwP can be referred for intermittent periods of time for either prevention or management. Depending on the person's priorities and contributing problems, a patient should be referred to either a physical therapist, to an occupational therapist, or to both, in order to receive optimal treatment. Referral to both professions for the same problem in daily functioning can be of additional value, because each discipline's perspective and approach is different and can complement each other. In Box 1, we describe an exemplary case of a PD patient who was treated both by a physical therapist and an occupational therapist. Recommendations for collaboration between disciplines are described below.

In the next paragraphs, we will describe the different and shared treatment approaches of PT and OT based on evidence-based guidelines [48,50] and review the most recent scientific evidence. We performed a narrative review in the database of PubMed using the following search strategy: 'physiotherapy', 'physical therapy' or 'exercise' or 'rehabilitation' or 'physical activity' or 'training' or 'occupational therapy' or 'functional training' or 'activities of daily living' and 'Parkinson' or 'Parkinson's disease' or 'Parkinsonism'. Additional references were identified through the reference lists. Articles were not systematically analyzed, but give a general overview of

Box 1.

Case*: Mrs. H is 67 years old and lives with her partner in a two-room bungalow. She has had Parkinson's disease for 7 years; H&Y stage 3.

Main problem: Difficulty cooking a meal. Referral to both OT and PT for analysis, advice and training.

Problem analysis OT: When cooking a meal, Mrs. H experiences incidental freezing in the crowded kitchen when turning to gather items. Due to slowed movement and reduced mental flexibility she has difficulty to manage multitasking and to handle the time pressure induced by the cooking task. As a result, not all dishes are ready simultaneously, after cooking the kitchen is chaos and Mrs. H feels exhausted. Her partner suggests it might be better to buy readymade meals. Mrs. H does not want to give up cooking and is eager to find ways of manage the activity better.
PT: Mrs. H has problems initiating walking as well as continuing walking when going through narrow spaces, upon full turns, and when doing dual tasks. Mrs. H responds well to weight shifting (left-right leg) to overcome freezing upon walking initiation, as well as to auditory cueing to continue walking.

Goal Within 6 weeks, Mrs. H is able to cook a simple two-person hot meal (maximum 2 pots) during four days a week without feeling exhausted.

Intervention/strategies- treatment: After explaining and discussing the problem-analysis and options with Mrs. and Mr. H, the following strategies are agreed upon and employed:
Person: The occupational therapist teaches Mrs. H to apply a structured planning strategy (cognitive compensatory strategy) for preparing meals to reduce time pressure and multitasking. She performs some preparation tasks earlier in the day. She learns to use a high stool at the kitchen sink to sit down when preparing vegetables. This prevents the need for dual motor tasking (i.e. maintaining balance while rinsing or cutting) and allows her to focus on the fine motor task. Mrs. H prefers to use musical cues in the kitchen. The physical therapist assesses the optimal cueing frequency and the preferred type of music. Using a 'beats per minute' analyser, the right songs are selected. The physical therapist trains Mrs. H in using these cues during walking and manoeuvring in small places at the clinic, as well as in Mrs. H's kitchen, also while carrying objects. Moreover, the physical therapist trains Mrs. H to use a one-off weight-shifting cue to start walking. Following this, the occupational therapist practices application of these learned strategies during an actual cooking task.

Context: Now Mr. and Mrs. H have insight into the contributing problems to the difficulty in cooking, the partner is advised by the occupational therapist to support his wife in her performance by allowing her to take sufficient time and by avoiding introducing extra tasks while she is cooking (e.g. no conversation). Following discussion with the occupational therapist, Mrs. H agrees to putting the small kitchen table with one end to the wall to create more space. Items in the cupboards are rearranged to reduce the number of required turns. A suitable stool is placed at easy access for activities at the kitchen sink.
Finally, the cooking task is simplified by performing the separate steps/tasks in a sequence (reduced multitasking) and by using some ready peeled potatoes and cut vegetable mixes. The frequency of preparing a fresh meal is reduced from 7 to 4 times a week. By cooking larger portions, the meals can be divided over the 7 days. *Based on [53]
*Based on [54]

Table 3. PT and OT: aim, scope and treatment.

	PT	OT
Aim	Maximizing movement quality, functional independence and general fitness; minimizing secondary complications; optimizing safety; supporting self-management and participation.	To enable patients to engage in meaningful roles and activities; support self-management
Scope	■ Gait (including freezing and posture) ■ Balance (including falls, fear of falls and posture) ■ Transfers (including posture) ■ Manual activities ■ Physical capacity (related to posture or inactivity	Patient: ■ self-care, domestic life and functional mobility ■ work (paid and unpaid) ■ leisure Caregiver: problems related to supporting the patient in daily activities
Treatment strategies	Education and coaching Advice for and training of the caregiver	
	■ Exercise ■ Practice ■ Movement strategy training	■ Compensatory strategies in activities (i.e. movement strategies, cognitive strategies and planning) ■ Optimizing day structure and routine ■ Adaptation of the physical environment
Treatment considerations	■ Considering fluctuations in daily functioning ■ Treatment site → home ■ Multidisciplinary collaboration ■ PD expertise	

evidence based practice for PT and OT that may also reflect the authors' personal bias.

Treatment strategies

Both PT and OT use education and coaching to empower the patient in self-management. The most important treatment strategies used by PT are (1) exercise; (2) practice and (3) compensatory strategy training (i.e. cueing and strategies for complex motor sequences) [48]. Occupational therapists mainly use a mix of strategies including (1) application of compensatory strategies in daily activities (i.e. movement strategies, cognitive strategies and planning); (2) adaptation of tasks and daily routines; and (3) adaptations of the physical environment. Both OT and PT provide advice for and training of the caregiver. In OT, specific caregiver interventions can also be addressed to the caregiver's personal goals related to supporting the patient in daily activities [50] (Table 3).

Education and coaching

As mentioned above, for both professions, it is essential that the approach and interventions fit with the abilities, needs, motivation and social context of the patient (and caregiver) [55,56]. Shared decision making regarding treatment goals and types of interventions is important to enhance a patient-centered approach.

Both OT and PT use education and coaching to optimize health literacy and to empower PwP to take an active role in adapting to the impact of the disease and to apply self-management. Specific attention should be given to the patient's personal role in preventing, recognizing and acting adequately towards (new) problems [48,50]. From a PT perspective, coaching is aimed to motivate PwP to engage in a physically active lifestyle. The recently developed and evaluated ParkFit program is an individualized coaching intervention given by a physical therapist aiming to increase physical activity. The results showed an increase in physical fitness and outdoor physical activity after 2 years of study duration [57,58].

The occupational therapist coaches PwP and caregivers to understand factors influencing their daily activities and participation, and to identify their own goals and opportunities in managing meaningful daily activities and routines. Evaluation of an individualized home-based OT intervention in which coaching was a core element, demonstrated effectiveness in increasing self-perceived performance and satisfaction in prioritized daily activities [59,60].

Exercise

Exercise consists of planned, structured and repetitive physical activity [61]. In PwP, exercise can be performed with different goals [62]. First, exercise addresses physical capacity and functional mobility, including balance, transfers and gait [48]. Second, exercise works as a symptomatic treatment, and this is particularly evident for suppression of motor symptoms [63,64]. Third, a recent systematic review showed that exercise also improves non-motor symptoms, such as depression, apathy and fatigue [65]. Lastly, adding cognitive elements to exercise has been shown to lead to both motor- and cognitive improvements in PwP [66,67]. One recent example in this field was the V-time study, which showed that an intervention combining treadmill training with non-immersive virtual reality reduced the risk of falls by nearly 60% more than treadmill training alone [68].

Cognitive elements can be added to exercise by, for example, gaming elements (the result is termed 'exergaming'). An example in this field is the ongoing Park-in-Shape study, where gaming elements are used to motivate patients to start an exercise, to make the exercise itself more playful and to reward patients after the exercise [69]. Finally, more recent work, studying the effect of physical activity in rodents, has suggested that physical activity might have a neuroprotective or neurorestorative effect [70–72], but there is to date no evidence to suggest that such effects are also taking place in exercising PwP.

Both aerobic exercise and strength training have shown to improve physical functioning and reduce disease symptoms [73–75]. The exact intensity, frequency and optimal combination between the two remain to be studied. Exercise to improve balance and gait is well established and is supported by evidence from multiple studies [48,61]. Recent studies have focused on technology-assisted training, for example using robot assisted treadmills [76] or equipment that provides preparatory cues and augmented feedback [77]. Evidence on the effectiveness of these new technologies is, at this point, still inconclusive [62] but there are clearly many possibilities for applying technology in future neurorehabilitation. In addition, specific exercise programs have been developed and studied recently. Potentially, effective programs are an Intensive Rehabilitation Program (4 weeks, 5 times a week, combined types of exercise) [78,79], and the Lee Silverman Voice Treatment – BIG program (high amplitude movements, sensory recalibration and self-cueing) [80]. Other types of exercise for which evidence is increasing are Tai Chi [81–83], hydrotherapy [84], boxing [85] and dancing [86–88]. There is very little evidence for exercise to improve hand function. A recent controlled pilot study found positive effects on dexterity and strength immediately following a single hand exercise session with therapeutic putty [89].

Practice

Practice refers to learning an original or new motor skill or motor task, taking into account personal goals. Performing repetitive movements with increasing complexity and positive feedback can improve (the fluency of) motor skills. Practice often includes cognitive engagement (e.g. cues and dual-tasks training) supported by the use of action observation and mental imagery and should be context specific [48]. For example, during dual-task gait training, PwP aim to improve walking parameters, using visual or auditory cues, while simultaneously undertaking a variety of motor or cognitive challenging tasks. The complexity of both the gait and additional task can be increased progressively. A randomized controlled trial evaluating dual-task training, the DUALITY trial, is underway [90]. In this trial, 120 PwP have been randomized to consecutive or integrated task practice. The first group has trained each task separately (e.g. gait practice and auditory cognitive exercises), whereas the second strategy proposed integrated dual task practice. The goal of this trial is to provide evidence about which strategy is the most effective in improving dual tasking and its results are expected to be published soon.

Movement strategy training

Cueing and attentional strategies

PwP that have difficulties with initiating or maintaining movement (e.g. gait) often report the use of stimuli from the environment to partly overcome these difficulties. For example, PwP may use the stripes of a zebra crossing to facilitate their walking. These sensory stimuli act as external cues to enhance the rhythm and scaling of automatic movements [91]. The presumed mechanisms underlying cueing have been proposed as activation of 'external' brain networks involving the cerebello-parieto-premotor loops, which makes up for the hypoactive basal ganglia-supplementary motor area that is constituting the 'internal' network [92]. Consequently, external cues may reduce the need to internally plan and prepare movements, taking on an executive role and decreasing cognitive load [93]. The use of cueing strategies can be exploited by both physical and occupational therapists [48,50,60]. They can help PwP to ascertain their best cueing modality, frequency and timing for the situations in which they experience problems with initiating or maintaining movements. The effectiveness of cueing on gait (including turning) in PD is well-established, even in the patient's home environment, without increasing the risk for falls [94–96]. Rhythmic auditory cues even seem to reduce the interference effect of a dual task on gait [93,97]. In upper limb activities, visual cues can improve handwriting [98] and self-vocalization or auditory cues can improve the kinematics of reaching [99–101]. In addition to external cues, attentional strategies can be used [48,50,102,103]. For example, PwP can be taught to focus on taking big steps while walking. Attentional strategies and external cues can be combined and have been shown to improve walking speed and stride length in single and dual-tasks, even in PwP with mild cognitive impairment [104]. Not all PwP benefit from cueing. The optimal cueing modality and parameter is patient-specific and depends on the person's preferences and abilities, the activity, the environmental context and underlying problem (initiation or continuation of movement, amplitude or speed of movement). Recently, new portable, user-friendly and personalized cueing devices have been developed. Examples include 'smart glasses' and 'laser walkers'. Even though these new technological inventions show great promise for personalized and continuous cueing (and are beginning to show positive effects in lab-based studies), further work remains needed to show effectiveness and cost-effectiveness in a real-life environment [32,105,106].

Strategies for complex motor sequences

Strategies for complex motor sequences (previously known as cognitive movement strategies) are used to improve the performance of complex movements, such as transfers and manual activities [48,50]. With this approach, complex, goal-directed movements, which can no longer be performed automatically, are broken down (reorganized) into simple movement components. [24,107]. These components then need to be performed in a defined sequence and with conscious control. Motor imagery can have a positive effect on motor performance and is therefore integrated in strategies for complex motor sequences [108]. The training should be tailored to the individual patient and should be task-specific (i.e. trained in the natural context) [48,50]. The steps involved in the selection and training of a strategy are shown in Box 2. Not all PwP will reach the final step of consciously controlled independent performance. In later stages, or when cognition becomes impaired, a caregiver might need to assist in recalling the steps or physically guide the movement.

Cognitive rehabilitation strategies

Occupational therapists can give advice about and train the use of compensatory cognitive strategies in daily tasks. These strategies are similar to the strategies applied to PwP with acquired brain injury: strategies for planning, problem solving and time pressure management [50,99,109]. The principles of compensatory strategies consist of setting up an external structure and ensuring a deliberate stepwise approach for planning, problem solving and monitoring activity performance [110]. Learning these strategies and integrating them in daily tasks and routines requires awareness of strengths and deficits, motivation and effort. When a patient cannot apply these strategies independently, a caregiver can be advised to offer guidance by providing an external structure. Environmental prompts may also act as a reminder.

Most cognition-related-intervention research in PD has focused on remedial cognitive training. The findings show that cognitive training is effective in the short term in improving the trained cognitive tasks, but these gains do not translate into daily activities and do not result in improvements in quality of life [111,112]. If cognitive skills are mildly affected, task performance can be improved by using compensatory cognitive strategies [110].

Optimizing day structure and routine

Structuring and planning the day is a strategy that can serve different types of goals [50,103]. First, a daily or weekly activity schedule can prompt memory and initiation of activities. Second, by carefully planning activities, stressful situations (i.e. time pressure, multitasking, crowded environments) can be anticipated and avoided. Third, this strategy can be used by PwP to handle fluctuating medication effects, slowness of activity performance and fatigue [33]. Adapting day structure and routines often means re-evaluating personal standards and values and resetting priorities. Patients with mild PD indicate that planning is 'helpful to get things done' [33]. In moderate and severe disease, the planning task itself can take too much time and effort and caregivers may need to assist [33]. An energy conservation group program, in which optimizing daily structure and routines was one of the strategies to manage fatigue, showed effectiveness in patients with multiple sclerosis and a mixed population of multiple sclerosis, post-polio and PD [113,114].

Adaptations of the physical environment

Because freezing and falls are partly influenced by constraints in the physical environment, assistive devices and modifications in the physical environment can

Box 2. Stepwise approach in selection and training of a strategy for complex motor sequences.

1. The therapist observes the patient in performing the activity to analyse which components of the activity are limited.
2. The therapist supports the patient in recognizing the activity and selecting the most optimal movement components. In general, this will be limited to four to six components.
3. The therapist summarizes the sequence of components in key phrases, preferably supported by visuals.
4. The therapist physically guides the patient in the performance.
5. The patient rehearses the steps aloud.
6. The patient uses motor imagery (mental training) of the consecutive movement components.
7. The patient carries out the components consecutively, consciously controlled, and if required guided by the use of external cues.

potentially enhance independence and safety, or reduce the amount of effort needed for activity performance. Physical therapists may offer advice on gait-related assistive devices, such as a cane or a wheeled rollator. Constantinescu et al. reviewed the available literature on gait assistive devices and concluded that canes can be very helpful for PwP with milder problems, walkers and walking stabilizers for those with moderate disability and motorized devices for those with severe disability. They mention, however, that assistive devices can sometimes worsen gait and increase falling. Therefore, device selection, adjustments and training should be assisted by an experienced physical therapist [115].

Occupational therapists can offer advice on the full range of assistive devices and modifications in the physical environment. Commonly advised modifications and devices in PD include: removal of obstacles, re-arranging furniture or working space, improving lighting conditions, optimizing height or support of furniture and using for example grab rails [50,103]. Structuring the environment and providing reminder-cues may be useful for PwP with cognitive deficits. The effectiveness of environmental adaptations has not been studied extensively in PD [116], but it has received considerable attention in the general population of elderly. OT has been found to be effective in decreasing falls in elderly at high risk of falling [117]. Moreover, a multicomponent home intervention has shown to improve quality of life and ameliorate functional difficulties with ambulation in community-dwelling elderly [118].

Advice for and training of the caregiver

The therapists can involve the caregiver in the treatment or address the caregiver's personal needs. Caregiver interventions include educating the caregiver about the effects of PD, training the caregiver in the specific skills needed to support the patient, provide information about relevant aids and adaptations that may reduce caregiver burden, and empower the caregiver to maintain or reacquire a healthy balance between personal activities and caring [50,103,119]. In a trial about home-based OT, the participating PwP, caregivers and therapists reported the benefits of actively involving the caregiver in the intervention [60]. Nevertheless, the trial showed a small positive effect on quality of life, but no effect on caregiver burden [59]. Finally, in the late stage of the disease or when the PwP is admitted to a nursing home, it is important to involve the nursing personnel in the treatment. They can be advised and trained in supporting PwP, for example by using compensatory strategies and cues [48].

General treatment considerations

Considering fluctuations in daily functioning

PwP who use dopaminergic medication often experience fluctuations in functioning during the course of the day: the so-called *on-off,* or *wearing off* states. Interventions aiming to increase physical capacity and to learn new strategies are recommended to take place when the capacity to learn is optimal (during the *on* phase). Once the patient is familiar with the strategies, it is important to train them at the moments when they are most needed (which is likely to be the *off* state, when disability is greatest).

Treatment site

Learning new skills is often task- and context-specific and the practice of tasks should preferably be provided in the patient's home environment [120]. Treatment at home has the additional advantages of enabling direct evaluation of the effect of new strategies and of meeting and involving the caregiver. A new development in this field is the use of telemedicine, which allows delivery of expert rehabilitation advice to the patient's own home (remote care). One study has shown that such a telemedicine approach is an effective way of offering patients access to care by a neurologist [121] and it will be interesting to develop and evaluate similar approaches for 'tele-rehabilitation'. Using new technologies also gives PwP the opportunity to integrate training or practice into daily life, for example by using exergaming [32].

Another emerging field is remote monitoring of daily functioning using wearable sensors and smartphones. Symptoms (e.g. voice, gait, falls) and physical activity can potentially be monitored continuously and in the patient's own daily environment. It is hoped that in the future, such information might be used by clinicians to make better-informed management decisions [122]. However, much work remains needed in this field, for example to demonstrate the feasibility of wearable sensor technology (e.g. compliance and usability), to develop reliable algorithms, and to study the impact on the clinical decision making process [123,124]. Finally, technology can be used to improve long-term adherence to various treatment strategies. A recent study explored the feasibility and acceptability of a virtual exercise coach to promote daily walking in PwP during one month. The mean adherence to daily walking was 85%. PwP successfully interacted with the virtual exercise coach and significant improvements were seen in mobility [125].

Multidisciplinary collaboration

A collaborative approach between OT and PT is successful when both disciplines focus on complementary, different aspects in both the assessment and interventions, while being aware of the instructions and strategies used by each other (see Box 1). To achieve this, full awareness of each other's expertise and effective and timely communication are essential [126]. Shared information should at least consist of the diagnostic results, treatment goals and the treatment plan. Contradictive interventions should be avoided and, when appropriate, treatment by OT, PT and other professionals should be sequenced in time to reduce the burden for the patient. Even though a multidisciplinary approach is intuitively the best approach when dealing with a complex patient population, evidence for the (cost-) effectiveness of multidisciplinary care in PD is conflicting [54,127–129]. Many different models of multidisciplinary and interdisciplinary care exist, and it is unclear which of those is most effective. Much more work remains needed in this area.

PD expertise

To deliver high quality care, it is important to involve health professionals that have sufficient PD-specific knowledge and expertise. In the Netherlands, PD care is organized in regional networks that consist of highly dedicated and specifically trained healthcare professionals in the field of PD: the ParkinsonNet approach [6,130]. Care is organized not in silos but in integrated networks, patients are engaged as partners in the healthcare process (e.g. via educational programs), and technology is used to facilitate communication and collaboration. Interprofessional collaboration is facilitated through regional network meetings and a web-based communication platform [6,130]. The aim of ParkinsonNet is to deliver high quality, individualized and integrated care to PwP and their families. The network has meanwhile reach full national coverage in the Netherlands, and now includes trained specialists from many different disciplines, including neurologists, PD nurse specialists, physical therapists and occupational therapists. Research has shown that this ParkinsonNet concept leads to greater concentration of care, better quality of care (e.g. better adherence to guidelines), better professional collaboration, fewer disease complications (including a 50% reduction in hip fractures) and substantially lower healthcare costs (an approximately 7.5% reduction in expenditures on chronic Parkinson care) [131,132]. Moreover, the participating professionals feel better empowered to treat PD patients, while patients themselves feel more secure [133].

Future perspectives

Both PT and OT have a unique as well as a shared role in PD care. Guided by a pallet of strategies, it is important to consider whom to involve and what the specific contribution of each discipline should be in reaching the patient's goals. Effective strategies for bundling their efforts into an effective multidisciplinary care model need to be developed and studied. A promising new tool in that regard is an online health community where professionals can meet online in a secured environment, to exchange experiences or discuss patients, and may provide a basis for multidisciplinary collaboration [134]. Evidence for the effects of allied health care interventions in PD is accumulating. Particularly PT has been studied extensively, and there is now good supporting evidence for many PT interventions [62]. Concerning OT, there is now initial evidence that an individually tailored home based intervention according to the OT guideline in PD is effective [59]. However, evidence what constitutes the most effective mix of strategies to address specific goals at different stages of disease is not yet available. For PT, there are strategies that lack evidence as well and optimal intensity, frequency and conditions are, in most cases, not known [62,135]. Clarke et al. performed a large RCT including 762 patients and concluded that both PT and OT were not associated with clinically meaningful improvements in activities of daily living or quality of life in mild to moderate PD [136]. However, a critical commentary has been published that mentions numerous flaws in the study design that threaten the internal and external validity of the results [137]. This shows that studying the effectiveness of allied healthcare interventions in PD is challenging for a number of reasons. Because of the heterogeneity of the population and the requirement for a personalized approach, it is inappropriate to study a 'standardized' treatment for the entire PD population. And it is challenging to define outcome measures that adequately capture the intervention effects. Future research should focus on elucidating which combinations of treatment strategies are most effective in specific patient groups. In the meantime, promotion of allied healthcare is justified based on increasing evidence. We should focus on implementing the interventions that already showed effectiveness, thereby increasing (social) participation and quality of life of PwP.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Prof. Bastiaan R. Bloem was supported by a center grant of the National Parkinson Foundation. Dr Nienke M. de Vries was supported by a research grant of the Netherlands Organisation for Health Research and Development.

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